

Colors, Luminosity Function and Counts of Galaxies

P. Saracco^{1,2}, G. Chincarini^{1,2}, A. Iovino²

¹*Dipartimento di Fisica, Università di Milano, Via Celoria 16, 20133 Milano, Italy*

²*Osservatorio Astronomico di Brera, Via Brera 28, 20121 Milano, Italy*

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ABSTRACT

Standard models for deep galaxy counts are based on luminosity functions (LF) with relatively flat faint end ($\alpha \sim -1.0$). Galaxy counts in the B-band exceed the prediction of such models by a factor of 2 to more than 5, forcing the introduction of strong luminosity and/or density evolution. Recently Marzke et al. (1994a) using the CfA redshift survey sample find that the number of galaxies in the range $-16 < M_{Zw} < -13$ exceeds the extrapolation of a flat faint end LF by a factor of 2. Here we show that this steep LF substantially contributes to justify the observed blue galaxy counts without invoking strong luminosity and/or density evolution. Furthermore we show that taking into account the variation of the $B - K$ color as a function of the morphological types and assuming a mean value $\langle B - K \rangle < 2.5$ for dwarf galaxies, we reproduce well also the observed K-band deep galaxy counts. This assumption is supported by the strong correlation we found between $B - K$ color of galaxies and their infrared absolute magnitude: galaxies become bluer with decreasing luminosity.

Key words: galaxies: luminosity function, colors, evolution

1 INTRODUCTION

One of the puzzle of observational cosmology is the different faint end slope of K-band and B-band galaxy counts. If one tries to reproduce deep blue galaxy counts using flat faint end luminosity functions (LF), as usually found in the literature (Tyson 1988; Broadhurst et al. 1988), and no luminosity evolution, the observed counts show an excess with respect to the expected predictions, excess that begins to appear at $B \sim 21$ (Maddox et al. 1990; , Jones et al. 1991; Lilly et al. 1991; Metcalfe et al. 1991; Loveday et al. 1992) or at $B \sim 22.5$ (Colless et al. 1990) rising to a factor of 5 up to $B \sim 25$ and continues unabated to the faintest levels observed at $B \sim 28$. The spread of this factor is dependent on the choice of Ω and of LF (see Koo and Kron 1992). The introduction of luminosity evolution to explain the excess in the B-band does not help, because the redshift distribution of B-band selected galaxy samples is best fitted by no-evolution (NE) models even at $B=24$, the faintest limit reached by spectroscopic surveys: the lack of a high-redshift tail in the redshift distributions rules out strong luminosity evolution of galaxies (Broadhurst et al 1988; Colles et al. 1990; Cowie et al. 1991; Colless et al. 1993). On the other hand, K-band counts show no excess above the no-evolution predictions up to $K \sim 21$ (Cowie et al., 1990 and Gardner et al., 1993). To solve the optical/infrared paradox, various models have been proposed, including the nonconservation of galaxy number due to mergers (White 1989; Cowie et al. 1991; Broadhurst et al 1992; Glazebrook, et al. 1994; Kauffmann et al. 1994) which would decrease the comoving num-

ber density of objects while increasing their luminosities; an entirely new population of dwarf galaxies that were present at high redshifts but absent today (Cowie 1991; Babul & Rees 1992); or dwarfs which have faded substantially in recent times (Broadhurst et al. 1988).

Koo & Kron (1992) suggest, however, that the faint field galaxy data could be explained without such exotic models. They found that a NE model (generated by *trial and error*) fits the data moderately well. Koo et al. (1993) and Gronwall & Koo (1995) improve on this approach assuming that the local luminosity function is not well defined and using a non-negative least squares technique to find the best fitting NE model. They find a good agreement between model and data in the case of a steep faint end LF. Analogous results are obtained by Driver et al. (1994) who present a model based on a significant number of dwarf galaxies, which accounts successfully for the number-count and color data without invoking evolution.

Various authors (Tamman et al. 1980; Davis & Huchra 1982; Shanks et al. 1984; Efsthathiou et al. 1988; Vettolani et al. 1992) agree with a faint end slope of about -1.0 for non cluster galaxies while in clusters others find much steeper faint end slopes such as $\alpha \leq -1.4$ (Ferguson & Sandage 1991; Bothun et al. 1991; Bernstein et al. 1995) and $\alpha \sim -2.0$ (De Propriis et al. 1995), due to the very steep LF of dwarf galaxies. The increasing contribution of dwarf galaxies to the faint end LF has been clearly evidenced also for field galaxies. Marzke, Huchra and Geller (1994a), using the CfA redshift survey sample, estimate the galaxy luminosity function over the absolute magni-

tude range $-22 \leq M_{Zw} \leq -13$. For galaxies with velocities $cz \geq 2500 \text{ Km s}^{-1}$ the LF is well represented by a Schechter function with parameters $\phi^* = 0.04 \pm 0.01 \text{ Mpc}^{-3}$, $M_{Zw}^* = -18.8 \pm 0.3$ and $\alpha = -1.0 \pm 0.2$. Including all galaxies with $cz \geq 500 \text{ Km s}^{-1}$ they find that the number of galaxies in the absolute magnitude range $-16 \leq M_Z \leq -13$ exceeds the extrapolation of the Schechter function by a factor of 2 and that this excess is due to the very steep LF obtained for the dwarf late type galaxies (Marzke et al. 1994b). This implies the existence of a population of intrinsically faint galaxies which dominates at faint magnitudes. In this work we investigate how the existence of a population of dwarf late type galaxies with a steep luminosity function affects deep B-band galaxy counts. Furthermore, we estimate which should be the $\langle B - K \rangle$ color of such population in order to avoid conflict with the deep K-band counts. Following the morphological classification of Binggeli (1993), we refer to Sm+Im galaxies as dwarfs. Throughout this paper we assume $H_0 = 100h \text{ Km s}^{-1} \text{ Mpc}^{-1}$.

2 GALAXY COUNTS MODEL

Galaxy counts are obtained by counting up all galaxies on a finite area of the sky. Let $n(m_\lambda, z)dm_\lambda dz$ be the number of galaxies between m_λ and $m_\lambda + dm_\lambda$ and z and $z + dz$, then we have

$$n(m_\lambda, z) = \frac{\omega}{4\pi} \frac{dV}{dz} \sum_i \phi_i(M_\lambda) \quad (0 \leq z \leq z_f)$$

where ω is the angular area in units of steradians over which the galaxies are counted and $\phi(M_\lambda)$ is the luminosity function for which the argument M_λ is differently related to m_λ through k-correction also depending on galaxy type i . The comoving volume $V(z)$ differentiated with respect to z is given by

$$\frac{dV}{dz} = \frac{4\pi cd_L^2}{H_0(1+z)^3(1+2q_0z)^{1/2}}$$

where d_L is the luminosity distance that in the Friedmann models with zero cosmological constant is defined as

$$d_L = \frac{c}{H_0 q_0^2} [q_0 z + (q_0 - 1)((1 + 2q_0 z)^{1/2} - 1)]$$

Integrating $n(m_\lambda, z)$ with respect to z we have the differential number counts

$$n(m_\lambda) = \int_0^{z_f} n(m_\lambda, z) dz$$

where z_f is the redshift of galaxy formation.

3 B-BAND GALAXY COUNTS

As a first attempt we compare the expected differential galaxy counts obtained by using the flat faint end LF (FFELF, $\alpha \sim -1.0$) of Marzke et al. (1994a) limited to $M_{Zw} < -16$, with respect to those obtained with the LF extended to the fainter magnitude $M_{Zw} \sim -13$ (SFELF, steep faint end LF). This last is a *total* LF made up of three Schechter functions, each one describing the luminosity distribution for the different morphological classes considered by Marzke et al. (1994b): the E+S0 galaxies, the

spiral galaxies (Sa-Sd) and the Sm+Im galaxies. Table 1 summarizes the M_{Zw}^* , α and ϕ^* fitted values of the different LFs. Figure 1 shows the Schechter functions for different classes and the total luminosity function (solid line), where the steep end is due to the contribution of dwarf late type galaxies.

A galaxy-type dependent luminosity function was previously used to construct galaxy counts models by Driver et al. (1994) and by Metcalfe et al. (1991; 1995). While the former assumes a LF not based on observations, the latter uses the Schechter function fits of Shanks et al. (1990). In particular, Shanks et al. find a value of $\alpha = -1.5$ for blue galaxies ($B - V < 0.6$), $\alpha = -1.1$ for galaxies with intermediate color ($0.6 < B - V < 0.85$) and $\alpha = -0.7$ for red galaxies ($B - V > 0.85$). The models of Metcalfe et al. (1991; 1995) use the red galaxy LF to describe E/S0/Sab, the intermediate LF for Sbc and the blue to describe Scd/Sdm galaxies, which is rather similar to the LFs obtained by Marzke et al. (1994a; 1994b) for the different morphological types.

We normalized the count models using a value of $\phi^* \sim 0.02 \text{ Mpc}^{-3}$, while keeping the relative morphological mixture estimated by Marzke et al. This value for ϕ^* is higher than that obtained e.g. by Loveday et al. (1992) but lower than those obtained by Marzke et al., Glazebrook et al. (1995a) and Lilly et al. (1995) for the luminosity function of galaxies. Our adopted value of ϕ^* is intermediate with respect to those estimated in the literature, while reproducing well the counts at bright magnitudes ($b_j < 19$). The general conclusions do not change substantially in case of a lower normalization (e.g. Loveday et al. 1992) or in case of a higher one (e.g. Glazebrook et al. 1995). A detailed discussion on the dependence of the counts models on the normalization used can be found in Metcalfe et al. (1991).

We transformed Zwicky magnitudes, m_{Zw} , to b_j magnitudes following Shanks et al. (1984)

$$b_j = m_{Zw} - 0.45$$

. The k -corrections used were taken from the polynomial fits of Ellis (1982) and Shanks et al. (1984) and are shown in Table 2. Their fits are based on the spectral energy distributions of Bruzual & Spinrad (1980) for E/S0 galaxies and combinations of the data of Pence (1976), Coleman et al. (1980) and Ellis et al. (1982) for the later types.

In Fig. 2 the differential number counts of galaxies in the b_j band in a one magnitude interval and in a unit area of 1 deg^2 are compared with models obtained by using the two different LF: FFELF and SFELF. Neither luminosity nor density evolutions have been considered.

We have transformed the number counts of different authors to photographic magnitude system, following the relations suggested by Metcalfe et al. (1991). In particular we have used

$$b_j \sim B_{Met} - 0.09$$

to transform the counts of Metcalfe et al. (1991; 1995) and

$$b_j \sim B_{Ty} + 0.04$$

to transform the data of Tyson (1988). No correction has been applied to the data of Jones et al. (1991), Maddox et al. (1990) and Lilly et al. (1991).

The difference between the two models begins to appear at $b_j \sim 21$ rising to a factor > 4 by $b_j \sim 27$. It must be re-

marked that the steep LF of dwarf galaxies found by Marzke et al. contributes substantially to the justification of the observed blue galaxy counts. However, the model with SFELF still underestimates the observed counts at faint magnitudes, showing that some level of evolution is required.

3.1 Merging and Luminosity Evolution

We will now determine how much of density and/or luminosity evolution is required having assumed the SFELF of Marzke et al. We assume that merging occurs in a self-similar way for all galaxies and that the total mass is conserved. In addition we assume that the proportions of different types of galaxies are maintained to conserve the shape of the luminosity function. Following Broadhurst et al. (1992) we adopted an exponential increasing galaxy number density ϕ^* with increasing look-back time δt :

$$\phi^*(\delta t) = \phi_0^* e^{\frac{Q}{\beta} \frac{\delta t}{t_0}} = \phi_0^* e^{-\frac{Q}{\beta} [(1+z)^{-\beta} - 1]}$$

where Q defines the merging rate and $\beta = 1 + (2q_0)^{0.6}/2$ (Peacock 1987). Due to mass conservation, the increasing number of galaxies is followed by a decrease of their mass. The characteristic mass \mathcal{M}^* of the galaxy mass function (Press and Schechter 1974) decreases with δt as

$$\mathcal{M}^*(\delta t) = \mathcal{M}_0^* e^{-\frac{Q}{\beta} \frac{\delta t}{t_0}}$$

and consequently, under the assumption of $\mathcal{M} \propto L$, the luminosity L^* will evolve in the same way and the characteristic magnitude will decrease as

$$M^*(\delta t) = M_0^* - 2.5 \frac{Q}{\beta} [(1+z)^{-\beta} - 1] \log e$$

The luminosity of distant galaxies also depends on the history of their star formation rate $R(\delta t)$. Under the assumption that R is proportional to the available gas, the star formation rate will evolve exponentially (Kennicutt 1983) as

$$R(\delta t) = R_0 e^{\frac{-b}{\beta} \frac{\delta t}{t_0}}$$

where b is the rate of the decline. As a first approximation, the increase in blue luminosity is proportional to R at modest redshifts. We assume that beyond $z \sim 1.5$ the value $b_j(z) - b_j(0)$ remains constant to avoid an unreasonable value of evolutionary luminosity correction.

In fig. 3, the expected galaxy counts in the b_j -band obtained for different rate of merging (Q) and of luminosity evolution (b) are compared with the data. In all cases, the SFELF and $z_f = 5$ have been assumed. We remark that count models are weakly dependent on the z_f value and therefore a wide range of z_f can be consistent with the data. Broadhurst et al. (1992) using analogous models and a flat faint end LF, obtain reasonable results only assuming a merging rate $Q = 4$ and an evolutionary luminosity correction rate $b = 4$. Fig. 3 shows that the existence of a raising faint end LF can justify the observed excess of blue counts at faint magnitudes avoiding a very strong luminosity evolution and/or a high merging activity: a value of $b = 2$ and $Q = 2$ provide a reasonable fits to the data even in the case $q_0 = 0.5$.

3.2 Implied Redshift Distribution

One question still remains open at this point: how well does a model with a steep LF and a mild amount of evolution agree with the observed redshift distribution? It is well known that the observed redshift distribution of optically selected samples is better fitted by a no-evolution model than by the evolutionary one. The observed distribution shows a peak shifted toward lower redshifts and a high-redshift tail less pronounced than that expected in the case of a simple luminosity evolution model (Cowie et al. 1991; Broadhurst et al. 1992). Merging activity, as in the Broadhurst et al. model, has the effect of decreasing the expected median redshift and of shortening the tail of the distribution, but observational evidences like the observed weak correlation among galaxies at $B = 25$ (Efsthathiou et al. 1991; Toth & Ostriker 1992; Dalcanton 1993) seem to rule out high merging activity.

The existence of a steep faint end LF contributes to the reconciliation of deep number counts with deep redshift survey. The direct effect of a steep LF is to decrease the expected median redshift and to increase the counts at faint apparent magnitudes. In Fig. 4 the strong dependence of the expected median redshift on the luminosity function slope is clearly shown. Fig. 5 shows the redshift distribution for the combined b_j -selected sample of Broadhurst et al. (1988) and Colless et al. (1990) limited to 22.5 (histogram). Fig. 6a and 6b show the redshift distributions of the 73% complete sample and of the 89% complete sample limited to $B = 24$ of Glazebrook et al. (1995b). The dotted line has been obtained under the assumption of no-luminosity and no-merging evolution and $q_0 = 0.5$. The dashed and the solid line have been obtained considering merging activity ($Q=1$ and $Q=2$) and moderate luminosity evolution ($b=1$ and $b=2$). They refer to $q_0 = 0.05$ and $q_0 = 0.5$ respectively. However, the extreme simplicity of the models does not allow to put constraints on q_0 .

The fit with the observations is good, except at very low redshifts where the number of galaxies observed is smaller than the number predicted. Many groups (Phillipps et al. 1987; Impey et al. 1988; Tyson & Scalo 1988; Bothun et al. 1991; McGaugh 1994; Ferguson & McGough 1995) have already shown that selection effects due to surface brightness drastically reduce the number of dwarf galaxies that we actually see. We suggest that this could also be the reason of the disagreement between observational data and model prediction at low redshifts: in the histogram the population of nearby dwarfs is underestimated. Observational and theoretical evidences support this statement. Raukema and Peterson (1995), using a survey for Low Surface Brightness Galaxies (LSBG), find that the resulting sample consists of dwarf galaxies with $z < 0.05$ and low luminosity as found in Virgo, Fornax and other galaxy clusters (Ferguson & Sandage 1991; De Propris et al. 1995). HST observations (Myungshin et al. 1995) indicates an excess of small versus large faint galaxies favoring the dwarf rich scenario. On the theoretical side Dalcanton, Spergel and Summers (1995) show that the formation LSBG is an unavoidable prediction of any hierarchical clustering scenario and that they make up most of the faint end of the galaxy LF.

4 K-BAND GALAXY COUNTS

Infrared selected samples are better suited to separate the effects of evolution and cosmology and therefore to impose constraints on the geometry of the universe. At these wavelengths, evolutionary effects are smaller because the counts are mainly sensitive to the light from the old stellar populations with ages comparable to those of the galaxies. In addition they are insensitive to changes in the star formation rate, the k-corrections are much less important and the uncertainties due to dust extinction are negligible.

Deep galaxy counts in the K -band are reasonably fitted by no evolution model with low q_0 : the excess found in the blue band tends to vanish (Cowie et al. 1994; Glazebrook et al. 1994). However, even in this case, a low rate of merging improves on the fit of the data. The expected K -band counts are usually obtained by shifting the optical LF by what is assumed to be the *mean* color of galaxies. Mobasher et al. (1993) find $M_K^* \sim -25$ and $M_{B_j}^* \sim -21$ in K and b_j band respectively and a slope of both the LFs consistent with $\alpha \sim -1.0$. With the estimated K -band LF Mobasher et al. find that the observed K -counts are well fitted by a merger model, with $q_0 = 0.5$ and a rate of merging $Q \sim 2$. However they estimate the LF over the absolute magnitude range $-27 < M_K < -22.5$ ($-23 < M_{b_j} < -18.5$) and therefore the faint end slope is unknown and the contribution of a possible steeper faint end is not taken into account. Recently Glazebrook et al. (1995a) estimate the luminosity function of a K -band selected galaxy sample finding an M_K^* one magnitude fainter than that of Mobasher et al., and their predicted number counts are below the observed ones at $K > 21$. The observed excess is explained as due to galaxies fainter than the typical luminosities probed in their luminosity function determination. They obtain a reasonable fit of the counts by adding an extra dwarf component (with $\phi_{dwarf}^* = 2\phi_{normal}^*$ and $\alpha = -1.8$) which steepens the faint end LF.

As a first step we predicted K -band counts using the SFELF used for the B -band and shifting each Schechter function by the mean $\langle b_j - K \rangle$ color relative to each morphological class as reported in the literature (see Tab.1). The k-corrections in this band are very insensitive to galaxy type over a wide redshift range, and act to brighten rather than fade the galaxy (see Fig.1 in Cowie et al. 1994). We approximate the k-corrections of Cowie et al. (1994) by polynomial fits. We used

$$k_K(z) = -1.1z + 0.43z^2 + 0.13z^3 - 0.05z^4$$

and

$$k_K(z) = -1.26z + 0.34z^2 + 0.07z^3 - 0.02z^4$$

for E+S0+S and Sm+Im respectively. In Fig. 7 the observed differential number-magnitude counts of Gardner et al. (1993) and Glazebrook et al. (1994) are compared with our models (normalized to fit the observed counts at $K = 15.5$ mag). There is tendency to overpredict the counts at faint magnitudes. The predicted excess is due to the steep LF of dwarf galaxies and it is strongly dependent by the $\langle b_j - K \rangle$ color assumed. If we chose $\langle b_j - K \rangle \sim 2$ for the dwarf galaxy component of the LF a very good agreement is found between observational data and the model with $q_0 = 0.5$ and $Q = 2$. We can therefore reconcile B and K -band galaxy counts assuming a value $\langle b_j - K \rangle \sim 2$ for the

dwarf galaxy component of the LF.

5 COLORS OF DWARF GALAXIES

How confidently can we assume $\langle b_j - K \rangle \sim 2$ for dwarf galaxies? Recillas et al. (1990; 1991) find that the $V - K$ color of early type cluster galaxies tends to increase with infrared luminosity. This result has also been found by Gavazzi (1993) who shows that the infrared luminosity of galaxies in the H band is a very good tracer of their dynamical mass and that the $B - H$ color tends to increase with mass for cluster galaxies of a given Hubble type (Gavazzi, Randone & Branchini 1995). It is reasonable to assume that infrared luminosity in the K -band is also a good tracer of the mass and, therefore, that also the $B - K$ color should increase with mass. In order to verify the existence of this trend for field galaxies, we used the optically selected sample of Bershadsky et al. (1994) complete down to $B \sim 20$, to construct a complete IR sample. The $B - K$ color distribution of this sample shows a relatively sharp cut-off at $B - K \sim 5$. This cut-off gives a crude estimate of the K -magnitude completeness: $K \sim 15$. To check this estimate we have applied the V/V_{max} test (Schmidt 1968) on the resultant 95 galaxies with magnitude $K < 15$. The estimated $V/V_{max} = 0.52 \pm 0.03$ supports our adopted magnitude limit. In Fig. 8 the $B - K$ colour vs K absolute magnitude for the IR selected subsample is shown. A strong correlation between the color of galaxies and their K luminosity is evident in the sense that brighter galaxies tend to have a larger $\langle B - K \rangle$ color. The systematic trend does not seem to decrease going to fainter magnitudes. The correlation found is well fitted by the relation

$$B - K = -(0.41 \pm 0.03)M_K - (5.0 \pm 0.7)$$

in good agreement with that obtained by Gavazzi (1993) for cluster galaxies. This correlation implies that, considering K luminosity as mass tracer, low mass galaxies (dwarf galaxies) are bluer than high mass galaxies. Extrapolating our relation to a color $B - K = 2$ and taking into account the errors in the fitted parameters, we derive an absolute B magnitude $M_B = -15 \pm 2$, which are the magnitudes at which the LF of Marzke et al. raises.

The correlation found implies also a dependence of the evolution of galaxies from their mass. It suggests that low mass galaxies are younger than the high mass ones and that the low mass red stellar population, with eventually some contribution by evolved giants, tends to dominate at larger galaxy masses. To support this statement there is also the discovery of a dwarf galaxy at $z = 0.2$, seemingly forming its first generation of population II stars (Tresse et al. 1993). Moreover most of the dwarf galaxies observed by Tresse et al. are star-forming galaxies at $z < 0.2$. Therefore it seems reasonable to assume a $\langle B - K \rangle \sim 2$ for dwarf galaxies.

SUMMARY AND CONCLUSIONS

It is well known that the expected counts of galaxies are strongly dependent on the luminosity function of galaxies and on its evolution. Since at the present we are unable to accurately estimate the LF at large redshifts, a way to proceed is by carefully evaluating the present day luminosity function in order to infer from it, and from the observed

counts, its evolution as a function of redshift. What is needed are estimates of the LF down to very faint magnitudes.

In this paper we have shown that the LF derived by Marzke et al. (1994a; 1994b), contributes substantially to justify the observed faint B -band galaxy counts. This imply that a population of intrinsically faint (local) blue galaxies is responsible at least of a part of the observed excess. This is supported by the results of Treese et al. (1993) who find a large population of dwarf galaxies at low redshifts and by the results of Landy et al. (1996) who conclude that a substantial fraction of blue galaxies must exist below a redshift $z = 0.3$.

However, to reach a good agreement with the observed B -band counts, we still need mild luminosity ($b = 2$) and density ($Q = 2$) evolution. By decreasing the required evolution we reach a better agreement with the HST observations at high redshifts, that show a moderate luminosity and density evolution (Myungshin et al. 1995; Forbes et al. 1995). With this model, we also reach a good agreement with the observed redshift distributions down to $B < 24$ (Glazebrook et al. 1995b). At low redshifts the number of observed galaxies is slightly smaller than the number predicted, although the differences are within 1 sigma. However, as suggested by McGaugh (1994) and Ferguson & McGaugh (1995), most of the redshift surveys could be biased against low surface brightness galaxies.

The K -band galaxy counts depend on the K -band luminosity function, usually obtained shifting by a mean $\langle B - K \rangle$ color the B -band luminosity function. In the literature the mean $\langle B - K \rangle$ adopted is 4-5, and applying such a value our count model with SFELF and moderate merging, would badly overestimates the observed K -band counts. The SFELF used in our models is not chosen *ad hoc*, but it is based on the observations derived by Marzke et al. for local galaxies. Moreover an analogous result is obtained by Lilly et al. (1995), who find an excess of blue galaxies at $z < 0.2$ with respect to a flat LF. Merging activity is also supported by some recent observational evidences and thus must be taken into account (Burkey et al. 1994; Colless et al. 1994; Myungshin et al. 1995).

Therefore to reconcile K -counts with the model fitting the B -band galaxy counts, we must hypothesize a flattening of the LF from B to K band i.e. the faint galaxies that contribute to the rising of the B -band LF should be bluer than the canonical value used in the literature. By assuming a mean $\langle B - K \rangle$ color that is a function of the morphological types and, in particular, a value of $\langle B - K \rangle < 2.5$ for dwarf galaxies, we are able to reach an agreement with the observed K -band galaxy counts.

Our suggested solution is supported by the strong correlation found between $B - K$ color and absolute IR K -magnitude: galaxies tend to be bluer with decreasing IR luminosity. This implies that, considering K luminosity as mass tracer, low mass galaxies (dwarf galaxies) are much bluer than high mass galaxies.

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Table 1.

Class	M*	α	ϕ^* (10^{-3}Mpc^3)	$\langle b_j - K \rangle$
E-S0	-18.87	-0.92	10	4.0
Sa-Sd	-18.76	-0.81	15	3.5
Sm-Im	-18.79	-1.87	0.6	2.5

Table 2.

Morphological type	k -corr (b_j)	Observed fraction ($b_j < 16.5$)
E	$4.14z - 0.44z^2$	0.04
S0	$4.14z - 0.44z^2$	0.39
Sab	$2.35z + 0.08z^2$	0.14
Sbc	$2.35z + 0.08z^2$	0.25
Scd	$1.95z - 0.26z^2$	0.11
Sdm	$1.22z - 0.24z^2$	0.07

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FIGURE CAPTION

Fig. 1 Schechter function fits for different morphological types (Marzke et al. 1994b). The solid line represents the SFELF.

Fig. 2 Expected number counts in one magnitude interval in a unit of 1 deg^2 for the FFELF (dotted line) and for the SFELF in the case of $q_0 = 0.5$ (dashed line) and $q_0 = 0.05$ (solid line). In both cases no-luminosity and no-density evolution have been considered.

Fig. 3 Expected number counts obtained by using the SFELF and different rates of merging (Q) and luminosity evolution (b).

Fig. 4 Expected redshift distribution for different LF slopes.

Fig. 5 Expected redshift distribution of a b_j -selected sample limited at 22.5 for the SFELF in case of no evolution (NE, dotted line) and for different rate of merging (Q) and luminosity evolution (b). The data are taken from Broadhurst et al. (1988) and Colles et al. (1990).

Fig. 6a and 6b As Fig. 5 for the sample of Glazebrook et al. (1995b) limited to $B=24$.

Fig. 7 K-band number-magnitude counts are compared with models. The dotted line has been obtained in case of no density evolution. The dashed and the solid refer to a merging rate $Q=2$ and to a $< b_j - k >$ color for the S_m+I_m galaxies of 2.5 and 1.9 respectively.

Fig. 8 Colour-luminosity diagram for the complete IR subsample extracted from the optically selected sample of Bershadsky et al. (1994). The typical photometric error is shown.

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